

MODIFICATION AND PERFORMANCE EVALUATION OF TRACTOR DRAWN RAISED BED SEED DRILL UNDER VERTISOL

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ABSTRACT

For the modification in tractor drawn (TD) raised bed seed drill with two beds forever machine, a furrow dresser was designed and drawn with the help of computer aided design package for adoption of raised bed technology for farmers, in clay loam soil (vertisol). This machine was evaluated and compared with the performance of a raised bed drill with three bed furrows, zero till drill and conventional practices at Jawaharlal Nehru Agricultural University farms for the chickpea sowing. It was found that the total time and cost required for making raised beds and sowing operations by raising bed drill was 1.42 h/ha and Rs.439.77/ha, which is 17.44% and 20.22% less time required than conventional sowing practices and zero, till drill practices respectively. The average yield by raising bed seed drill was 1211.3 kg/ha. Whereas, by conventional practices and tractor drawn zero till drill was 1127.83 kg/ha and 1137.8 kg/ha, respectively. The soil conditions were also found better in the case of the T.D. Raised bed seed drill machine.

KEYWORDS: Raised Bed Seed Drill, Furrow Dresser Design & Performance Evaluation

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INTRODUCTION

Raised bed was introduced to the Rice - Wheat system of the IGP in the mid 1990s. Initially, for wheat impaired by the success of irrigated maize, wheat on permanent raised bed in Mexico. It has benefits to overcome the water logging and improve soil structure on the cropping, soil in the high rainfall zone as compare to the conventional seed drill. Improve soil structure, proper aeration and proper drainage of soil to benefit the achieving of high yield. It is adopted for the grown high value crop that is susceptible to water logging stresses such as maize, cotton, wheat, and chickpea. The raised bed system facilitates irrigation through the furrow. In order to effect further sowing in irrigation water, its system also allows alternate or skip furrow irrigation. Furrow irrigation in raised bed system is a rationale water sowing technology, and reduce soil erosion, save irrigating water and costly.

In the past, many of raised beds have been designed by scientist, who is giving good result under light soil. However, it is found that its performance is not up to mark of satisfaction as problem arises in compaction, penetration and slope of the bed. Modified raised bed give better result under the heavy soil condition. In the testing, the items to be measured and performance, working, capacity, field efficiency, power requirement, yield in comparison with the conventional seed drill.

METHODS AND MATERIALS

The machine consists of a 4 tine, 2 raised bed furrow openers along with the covering devices and seed-cum-fertilizer drill. The machine was designed with an AutoCAD 2013 Computer graphic package. The conceptual and orthographic design views of the raised bed furrow openers as well as isometric & orthographic design views of the machine are given figure 1 & 2. The overall specifications of the machine are given in table 4.

Raised Bed Seed Cum Fertilizer Drill Description

The raised bed type furrow opener (Figure 1) consists of furrow openers, a tine, a shovel, a boot and tubes for seed and fertilizer. The furrow openers are 87 cm long, while the width of the bed-maker is 1.20 m. Point shear 40cm long and 7 cm width at a distance of two wings have been provided with fore and aft to open opposite end. Triangular furrows with 40 cm top width and depth each is made with this shaper. However, the bed width and furrow depth are adjustable. Tine should be made of flat mild steel flat having a width of 55 to 75 mm and thickness of 15 to 18 mm. Boot and tube should be made of mild steel with a minimum thickness of 1.8 to 2.0 mm and shovel material should be high carbon steel having minimum carbon content of 0.5 %. The shovel should be heat-treated with a minimum hardness in the range of 350 to 450 HB. Thickness of the shovel should be 3.0 to 4.0 mm. The furrow opener tines are made of mild steel, while the shoe or shovel of the opener is made of wear resistant high carbon steel (0.5 to 0.6% C, 0.65 % S and 0.05 % P). Figure 2 shows complete drawing views of raised bed seed cum fertilizer drill. Initially, the design and drawing of the furrow dresser were made with the help of "Auto CAD 2013" computer designing package, individually. After that, the furrow dresser was attached with the seed cum fertilizer drill with an appropriate attachment. The attachment was also designed and drawn with the help of an Auto CAD package, which include all the design and drawing parameters, such as weight, load, length and width of total machine.

The making of computer generic 3D-solid modeling for the modification of the individual part of furrow dressing and their assemblies for the individual and completely combine machine, i.e. raised bed seed cum fertilizer drill are given in following steps:-

Designing of Furrow Dresser

General Design Consideration of Furrow Dresser

Functional Requirements

- To drag the remaining soil just behind the furrowed of the raised bed drill.
- To shape and compact uniformly of the drain line and raised bed of sowing.
- To cover the seed uniformly in the soil.

Economical Consideration

- The cost of the furrow dresser should be as low so, that small farmers can afford to purchase the machine.
- The material of construction should be easily and locally available.

Field Testing

- Crop to be sown

- Field condition
- Available power source.

Block diagram of furrow dresser is given in the figure 1 and isometric and orthographic (solid section) diagram of furrow dresser is shown in figure 2.

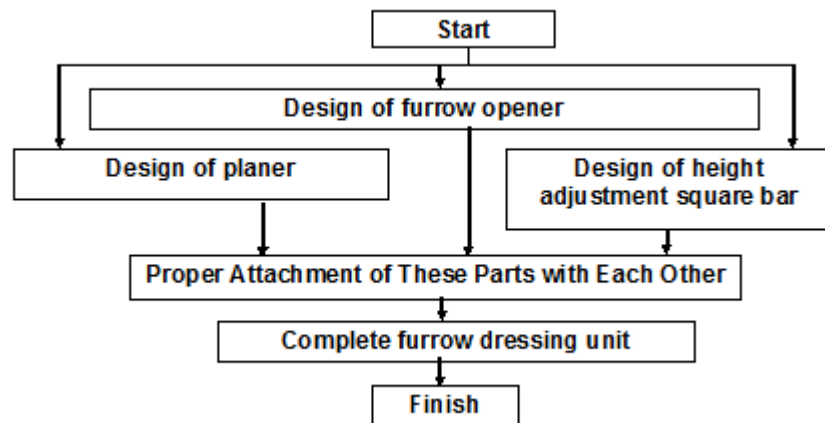


Figure 1: Block Diagram of Furrow Dresser

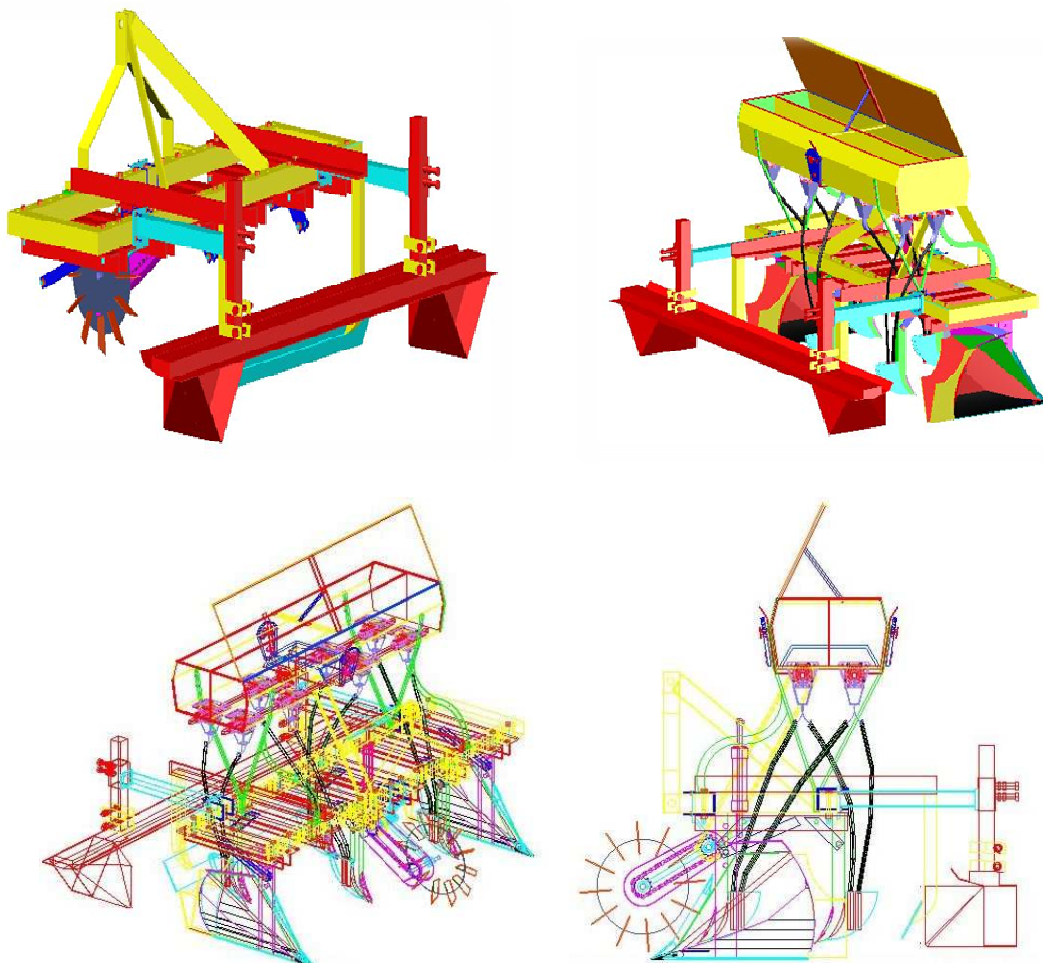


Figure 2: Isometric and Orthographic (Solid Section) Diagram of Furrow Dresser

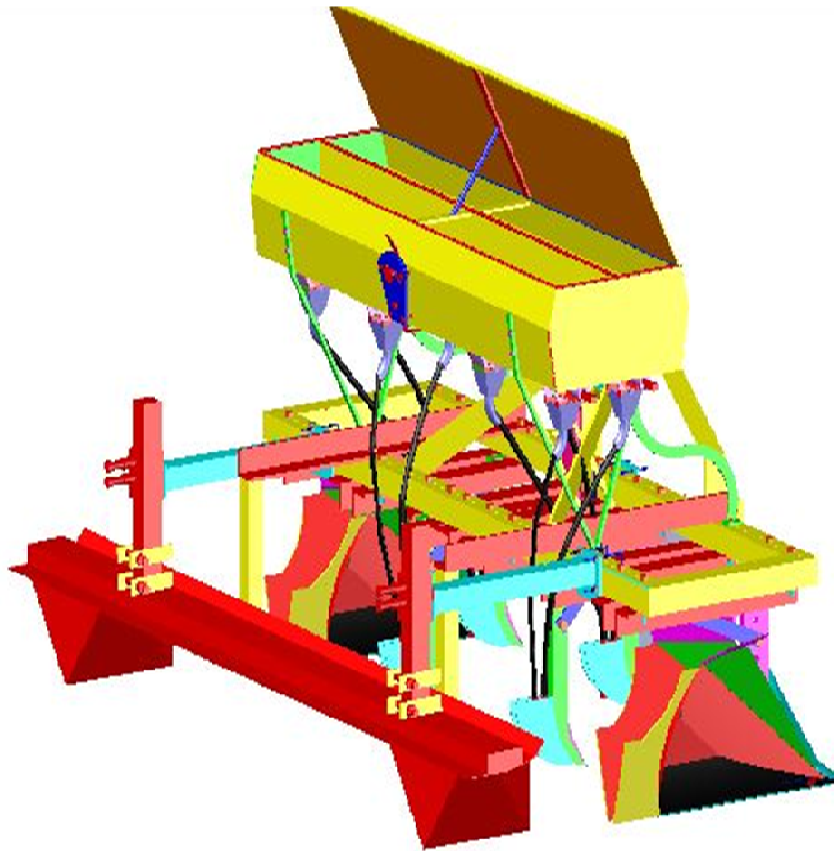


Figure 3: Isometric and Orthographic Diagram of Raised Bed Seed Cum Fertilizer Drill

The minimum diameter of seed and fertilizer tubes should be 50 mm, and they should be so placed that, center to center distance between seed and fertilizer tubes be minimum 50 mm. The lower tip of the fertilizer tubes should be 10 mm below the tip of the seed tubes and should be minimum 25 mm above the lowest point of the boot

Design of Tine of the Furrow opener

The shape of the tine is determined by slope l_1 and the radius of curvature R , which is dependent on load angle α of the shovel. Thus,

$$R = \frac{h_0 - l_1 \sin \alpha}{\cos \alpha} \quad \text{eq (1)}$$

The length of the inclined part of the tine generally ranges from 100 to 200 mm, and the radius of curvature $R < 120$ mm. The minimum clearance H_1 between the land surface and the lower edge of the frame should be 200 mm. Height of the tine is given by:

$$H = a_{\max} + H_1 + H$$

The tine of the furrow opener is exposed first of all, to bending in consequence of soil resistance. The soil resistance (F_0) is horizontal and acts in the axis of symmetry of shoe or shovel. The soil resistance is assumed to be 3 to 5 times higher than actual average soil resistance (F_x) offered by the particular soil. The value of the actual average soil resistance is obtained by the formula:

$$F_x = a W_w P_k \quad \text{(eq 2)}$$

Stress, causing the time to bend is given by the expression:

$$\sigma = \frac{6F_0(H_1 + a)}{b_1 t^2} \quad (\text{eq 3})$$

Torsional stress acting on the tine, when turning the openers inside the soil at headland is given by.

$$\tau = \frac{9F_0 W_w}{8t b_1^2} \quad (\text{eq 4})$$

Reduced stress amounts to

$$\sigma_{zx} = \sqrt{\sigma^2 + 4\tau^2} \quad (\text{eq 5})$$

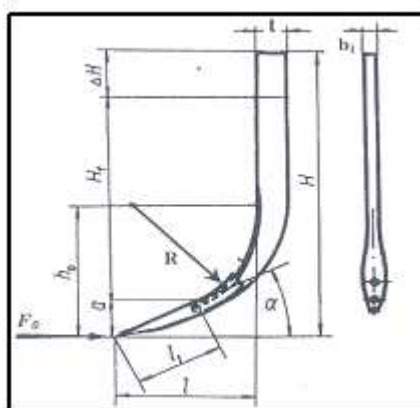


Figure 4: Dimension of Tine of Furrow Opener

Since, the tine of the furrow opener is sinking into the soil; thickness should be kept to a minimum. The most assumed ratio of thickness of the width of time is taken as 1:3 to: 4. The performance of the tractor drawn raised bed seed drill and different sowing systems was evaluated in 0.15 ha fields, and the field experiments were carried out at the BSP research farm of J.N.K.V.V during December 19, 2014. The field being a low lying area was poorly drained. The soil of the experimental field was classified as rich clay-loam (vertisol) and the percentage of clay; silt and sand were in the range of 50.75, 20.15 and 29.10 per cent, respectively. In the field, under each condition was divided into four tillage treatment blocks. Each field was further divided into six equal parts of size 10m X 3.6m. The experiments were conducted using a randomized block design. The machine performance was compared with the conventional practices and zero tillage drill for chickpea cultivation. Details of the tillage treatments and sowing system are given below:

T₁ = Zero tillage

S₁ = Zero till seed cum fertilizer drill

T₂ = Cultivator x 1 + Disc harrow x 1

S₂ = Conventional seed cum fertilizer drill

T₃ = Cultivator x 1 + Disc harrow x 2

S₃ = Broadcasting

T₄ = Cultivator x 2 + Disc harrow x 2

S₄ = Raised bed seed drill with 3 bed furrower

S₅ = Raised bed seed drill with 2 bed furrower

Speed, draft, time, fuel required and other machine parameter were recorded for each operation of tillage

implement and sowing machine and their field capacity, field efficiency and energy requirement were calculated. JG-14 chickpea variety was used for the performance evaluation of sowing system. The recommended rate of 80kg/ha of seed and 20 kg/ha N, 60 kg/ha P_2O_5 kg/ha and 20 kg/ha K_2O was applied at time of sowing. Further, irrigations were required during the crop season.

RESULTS AND DISCUSSIONS

Effect of Furrow Dresser for Making of the Bed Furrower

Furrow dresser was designed and drawn by using AutoCAD design software, and then, this furrow dresser was fabricated in the workshop.

For evaluation of the effect of a furrow dresser for the making of bed furrow, the cross sectional area of the furrow with tractor drawn raised bed drill, with furrow dresser and without furrow dresser was measured in the actual field conditions. Their performance was evaluated by measuring the cross-sectional area of the bed furrow, their penetration and compactness of the soil. It was found that there was 32.14% of difference was found in the area of furrow with and without furrow dresser. So, it seems that dresser was formed good furrow in the field. The cross-sectional area of bed furrow was considerable difference between both operations of the raised bed drill machine (with and without furrow dresser). The difference between width, height and whole cross sectional area of bed furrow is given in table 1.

Machine Parameter

The speed of cultivator was similar i.e. 3.5 and 3.6 km/h in T_2 and T_3 treatment, respectively. The speed was found in the case of cultivator with one pass in T_4 as 3.7 km/h, cultivator with two passes as 3.9 km/h. The speed was found in case of disc harrow with one pass in T_3 as 4.2 km/h, disc harrow with two pass 4.6 km/h as, respectively. Similarly, disc harrow speed was found in case of T_4 as 4.1 and 4.5, respectively. The reason of more speed in case of disc harrow may be attributed to that, the passive tools required less draft and after single operation of cultivating the soil was tilted and manipulated nicely. The best tillage treatment for convectional seed cum fertilizer drill was found to be under the treatment T_4 . The best sowing machine for all thee treatment, which has required high speed for sowing operation was 3.5 km/h in case of conventional seed cum fertilizer drill. The similar results were also reported by other researchers, namely Ajeet Kumar *et al.* (2013), Shrivastava *et al.* (2012), and Mustafa and Nihat (2002).

The total draft of disc harrow was the maximum I. e. 6.37 kN in T_2 treatment and in cultivator with one pass 6.29 kN, cultivator with two passes and disc harrow with one pass, draft was maximum in T_2 treatment. A draft of the sowing machinery was maximum in raised bed drill with 2 bed forever (S_5) and minimum in case of conventional seed drill (S_2) sowing. The overall all maximum and minimum draft of all tillage and sowing combination was found to be 4.6 in in the T_4S_5 and 2.14 kN T_4S_2 treatments, respectively. The similar results were also reported by other researchers namely, Singh and Singh (1998) and Prasad (1995).

The maximum and minimum field capacity of cultivator was found 0.71 and 0.67ha/h in tillage treatment T_4 and T_2 , respectively. Similarly, the maximum and minimum field capacity of disc harrow was found 0.92 and 0.62 ha/h in tillage treatment T_3 and T_2 , respectively, and the maximum and minimum effective field capacity was found 0.72 ha/h in case of raised bed drill and lowest found 0.56 in case of zero till seed cum fertilizer drill. The similar results were also reported by other researchers, namely Ajeet Kumar *et al.* (2013), Shrivastava *et al.* (2012), Khan *et al.* (1990) and Menon *et al.* (2007).

The maximum field efficiency of cultivator was obtained 87.6% in T₄. Maximum field efficiency of cultivator with one pass, cultivator with two passes and disc harrow with one pass and disc harrow with two pass was found to be 85.7, 87.6, 85.25 and 86.65% in treatment T₄ respectively, as the draft of these implement was lower in T₂ as compared to the other treatments. Therefore, it had more speed which enhanced the field efficiency of implements, and the maximum field efficiency of all sewing machines was found to be 86.1% in case of T₄S₂ and minimum field efficiency was found to be 76.0%, in case of T₄S₅ treatments. The similar results were also reported by other researchers, namely Bauer *et al.* (1991).

The total time required for seed bed preparation in T₂, T₃ and T₄ was obtained 2.78, 3.74 and 5.13 h/ha respectively. In T₁ treatment time required was 25.66% less than T₃ and 45.8% less than T₄ for seedbed preparation, as in T₂ one operation of disc harrow was less than T₃ and in T₄ field was plowed by twice with a cultivator and twice with a disc harrow so time requirement was less in T₂ compared to T₃ and T₄ and the maximum and minimum time requirement of all treatment was found to be 1.78 h/ha in T₁S₁ and 1.38 h/ha in T₄S₅ treatments, respectively. The similar results were also reported by other researchers, namely Samerajeeva *et al.* (1995) and Singh *et al.* (1998).

The total fuel consumption in seed bed preparation under T₂, T₃ and T₄ was 10.1, 12.96 and 18.04 l/ha respectively. In T₂ treatment, fuel consumption was 22.06% less than T₃ and 44.01% more than T₄ for seed bed preparation. In T₂, one operation of disc harrow was less than T₃ and in T₃ field was plowed twice by the cultivator and disc harrow therefore, time requirement was more in T₄ compared to T₃ and T₂ and The maximum and minimum fuel consumption was found to be 7.65 l/ha in case of T₁S₁, and 5.1 in case of T₄S₅ treatments, respectively. The similar results were also reported by other researchers, namely Kumar and Thakur (1999) and Khan *et al.* (1990).

The Table 2 shows the average performance results of all tillage treatment and sowing systems under vertices. It was revealed from the table that the maximum time for seed bed preparation and sowing operation was with T₄S₂ at 6.84 h/ha and the minimum was T₁S₁ with 1.78 h/ha followed by T₄S₄ i.e. 6.59 h/ha and T₄S₅ i.e. 6.62 h/ha. This means that conventional practices required 73.7%, 3.65%, and 3.21% more time than T₁S₁, T₄S₄ and T₄S₅.

The maximum fuel consumption was found to be in treatment T₄S₅ (cultivator with one pass + cultivator with two pass + disc harrow with one pass + disc harrow with two passes + raised bed seed drill with 2 bed forever), the fuel consumption was the highest because, the operation includes field preparation using a cultivator with two pass and disc harrow with two passes, and then sowing was using raised bed seed drill with 2 bed for ever. The fuel consumption in treatment T₁S₁ was lowest, because sowing was done directly in the field, without any soil manipulation. The T₂S₂ fuel consumption, in case of conventional seed cum fertilizer drill required 53.63% more than T₁S₁ (Zero till seed cum fertilizer drill sowing).

CONCLUSIONS

The result of the testing shows that the modified raised bed sowing machine gave problem free and better performance than the other conventional sowing treatments.

- The time required for completing the work by tractor drawn cultivator x 1 + Disc harrow x 1 + seed drill x 1 was 72.27% higher than tractor drawn zero till seed cum-fertilizer drill, and 72.32% more than tractor drawn till plant machine. The operation cost was found to be minimum in case of tractor drawn zero till seed cum-fertilizer drill i.e. Rs. 1899.56 which is 28.86% less than tractor drawn cultivator x 1 + Disc harrow x 1 + seed drill x 1 and

almost equal to tractor drawn till plant machine. The yield was obtained in the case of treatment tractor drawn till plant machine i.e. 25.89 q/ha, which is slightly more than tractor drawn cultivator x 1 + Disc harrow x 1 + seed drill x 1. And, tractor drawn till plant machine, i.e. 25.61, 24.72 q/ ha, respectively, which is shown in table 3. Therefore, tractor drawn till plant machineries recommended as the best treatment among others.

- Farmers can perform seed bed preparation and sowing operations simultaneously, and can conserve time, fuel irrigation and manpower with a reduction in the cost of operation, by using the tractor drawn improved till plant machine.
- In a double cropped situation due to late harvesting of the paddy, the wheat is generally sown late, as the field conditions don't permit conventional tillage and sowing. In some cases direct drilling has special significance for timely planting of wheat, for better establishment growth and yield.
- The Auto CAD computer software package is a very powerful, helpful & precise tool for drawing, drafting & 3-D visualization of the objects, with technical considerations before manufacturing.

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APPENDICES

Table 1: The difference between Width, Height and Whole Cross Sectional Area of Bed Furrow

Parameter	Bed Furrow Dimension with Operation of Furrow Dresser	Bed furrow Dimension without Operation of Furrow Dresser
Width	36 cm	33 cm
Height	20.4 cm	15.1 cm
Area	367.2 cm ²	249.15 cm ²

Table 2: Performance Results of Different Machines

S.N.	Particulars	Treatment T ₁	Treatment T ₂			Treatment T ₃				Treatment T ₄								
		ZTSCFD	Cul x1	DH x1	CS-CFD	Cul X1	DH x1	DH x2	CS-CFD	Cul x1	Cul x2	DH x1	DH x2	CS-CFD	BD		RBD-3BF	RBD-2BF
1	Date of test	20/12/2013	12/12/2013	13/12/2013	19/12/2013	12/12/2013	13/12/2013	14/12/2013	19/12/2013	12/12/2013	12/12/2013	13/12/2013	14/12/2013	19/12/2013	19/12/2013	21/12/2013	21/12/2013	
2	Topography of soil	Plain	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
3	Type of soil	Clay loam	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	
4	Soil moisture content %	23.97	25.3	24.8	22.3	25.5	25.1	24.2	21.3	24.5	23.8	23.7	23.2	21.9	22.4	19.87	20.32	
5	Av. Depth of cut, cm	4.1	10.3	10.1	5.2	10.8	9.4	10.3	5.5	9.95	10.7	9.22	10.3	5.7	-	5.1	5.3	
6	Av. Width of operation m	1.762	1.92	2.01	1.77	1.91	2.02	2.03	1.78	1.91	1.92	2.01	2.02	1.78	-	2.258	2.269	
7	Av. Speed of operation, km / h	3.2	3.5	4.1	3.3	3.6	4.2	4.6	3.4	3.7	3.9	4.1	4.5	3.5	-	3.2	3.0	
8	Draft, kN	3.1	5.78	6.23	2.56	5.96	6.35	5.83	2.48	6.29	5.44	6.37	5.6	2.42	-	3.9	4.6	
9	Theoretical field capacity, ha / h	0.72	0.79	1.01	0.72	0.79	1.01	1.05	0.72					0.72	-	0.92	0.92	
10	Field capacity, ha / h	0.56	0.57	0.82	0.58	0.68	0.84	0.92	0.60	0.67	0.71	0.86	0.91	0.62	-	0.72	0.68	
11	Time required for 1 ha, (h/ha)	1.78	1.49	1.21	1.72	1.47	1.19	1.09	1.66	1.47	1.4	1.16	1.10	1.61	-	1.38	1.47	
12	Total time required for seed bed preparation and sowing operation0	1.78	4.34			5.33				5.13				6.84	5.09		6.59	6.62
13	Field efficiency, %	77.78	84.8	81.1	80.5	86.0	83.1		87.6	83.3	85.7	87.6	85.2	86.6	86.1	-	78.2	73.9
14	Fuel consumption, (lit/h)	4.3	3.7	3.8	3.9	3.4	3.6		3.4	3.6					3.4	-	3.7	3.8
15	Fuel consumption, lit/ ha	7.65	5.51	4.59	6.70	4.99	4.28		3.69	5.97	5.39	4.62	4.32	3.71	5.47		5.10	5.58
16	Cost of operation, Rs/ ha,	321.06	425	360	350	425	360		360	350	425	425	360	360	350	-	400	440
17	Total yield, q/ ha	11.37	-	-	10.1	-	-		-	11.0	-	-	-	-	11.2	10.0	11.6	12.1

ZTSCFD = Zero till seed cum fertilizer drill, **Cul**= Cultivator, **DH** = Disc harrow, **CSCFD** = Conventional seed cum fertilizer drill, **BD** = Broadcasting

RBD-3BF = Raised bed seed drill with three bed furrower, **RBD-2BF** = Raised bed seed drill with three bed

furrower, P = plain, CL= clay loam

Table 3: Seed Yield, Straw Yield, Straw to Grain Ratio and Weight of 100 Grain of Chickpea

S.N.	Treatments	Seed Yield(kg/ha)	Straw Yield (kg/ha)	Straw to Grain Ratio	Weight of 100 Grain
1.	T ₁ S ₁	1137.8	3674.5	2.74	27.8
2.	T ₂ S ₂	1014.2	3129.96	2.57	26.96
3.	T ₃ S ₂	1106.17	3252.44	2.65	26.6
4.	T ₄ S ₂	1127.83	3314.54	2.53	27.2
5.	T ₄ S ₃	1008.5	3561.26	2.78	26.52
6.	T ₄ S ₄	1165.29	2631.44	2.14	26.23
7.	T ₄ S ₅	1211.3	3022.26	2.18	28.43

Table 4: Specification of Tractor Drawn Raised Bed Seed Drill

S. No.	Particulars	Size
1.	Length (mm)	2000
2.	Width (mm)	560
3.	Height (mm)	1024
4.	Seed Metering Mechanism	Fluted roller type
5.	Fertilizer Metering Mechanism	Gravity feed or corrugated roller type
6.	Power transmission	Through chain & sprocket
7.	Furrow openers	Duck foot shovel type
8.	No. of Furrow openers	4
9.	Size of feed shaft (mm)	16-18
10.	Size (diameter) and no. of flutes	42.07(approx.) & 9
11.	Diameter of fluted roller (mm)	42.07(approx.)
12.	Size of fertilizer shaft (mm)	20-22.5
13.	Ground wheel diameter(mm)	390-450